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ABSTRACT

The first step in determining how to prepare the future teachers who will teach in the field of technology education in the 21st century is to determine what technology education itself will be like. If one purpose of technology education is to prepare people to adapt to new situations and control their own destinies, then the role of educators in the technologies should be to determine what learning is of most worth in the ever-changing, dynamic, worldwide technological society. Traditionally, educators have separated liberal education from technological education. This can no longer be the case. Teacher education programs must be revamped radically and must receive adequate staffing and funding to prepare future teachers who will be able to provide technology education that is both job specific and broad enough to focus on the role of the individual in a free society. Research is necessary to develop pedagogical methods adequate to prepare teachers who can fuse the knowledge about the concepts, relationships, and consequences of technical means with the knowledge and know-how for using and designing appropriate technical means. (MN)

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Educational Excellence Through KIEA In-service

Technical Foundation of America Distinguished Lecture

Presenter: Paul W. DeVore
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West Virginia University

Title of Presentation: Preparing the Technology Education Profession for the Future

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Preparing the Technology Education Profession for the Future

The World of Today and Tomorrow

We are no longer an isolated nation. We no longer are in control of our own destiny. We live in an interdependent changing world, a world of accelerating industrialization, rapid population growth, widespread malnutrition, increasing depletion of non-renewable sources of minerals and energy and a deteriorating environment.

Our futures are linked irreversibly to the rest of the world. More and more people of the world are dependent on each other, whether the context is the environment, raw materials, energy supply, finished products, food supply, or knowledge and know-how. The advent of television and communication satellites and the resulting rising expectations of people throughout the world, coupled with the microprocessor and its potential for accelerating the pace of technological change, portend a future far different from the present.

How should a profession concerned about educating people about technology prepare for the future? How should we prepare our future teachers, those that will teach in the field of technology education in the 21st century? Certainly the future will be different from today. Change is and will be a constant because we have institutionalized

change. We invest in it. We plan for it. It is on-going and the evidence is abundant. Changes today are affecting many people in many ways.

On a local scale we find that many of our neighbors are unemployed and perhaps will never return to their former place of work. Those who are employed have discovered that, because of continual inflation and cyclic recessions, they cannot maintain a life style that only a few years ago was considered normal. This is true for millions of well educated middle class people.

We are finding that the United States is no longer competitive in heavy industries, and faces heavy competition from other nations in the development and production of computers, machine tools, construction equipment, automobiles, textiles, electronics and home appliances. Our mounting and continuing trade deficits are manifestations of these events.

In less than eighty years the United States has changed from an agricultural, to an industrial, to a service economy. Manufacturing, mining and construction combined account for only 35 percent of the current jobs in the United States. It is predicted by various sources that by 1990 the service sector--banking, insurance, communication and information industries and fast food restaurants--will provide 80 percent

of the jobs. Many jobs in these fields are low in pay and offer few career advancement opportunities.

The heavy industries--steel, auto, and machine tools--will be replaced in the economy by businesses and industries that facilitate, move, service, and manage rather than make things. Manufacturing firms have been and are moving their operations to other countries for a variety of reasons including lower wages. The new plants utilize the most sophisticated equipment and management techniques.

The new era we have entered is focused on electronic computing equipment, telecommunications, instrumentation and control devices, the health fields, entertainment equipment and space vehicles and satellites. Some of the new communication firms are already recording market values twice those of the large steel and aluminum producers.

These changes have been brought about by human endeavors in creating and using technical means. Major changes in society have always come about when human potential was altered through developments in the technical means which provided:

1. A more stable food supply
2. New and better materials
3. Alternative forms of energy supply
4. A more efficient means of energy conversion

5. A more efficient means to:
   a. collect
   b. store
   c. transmit and
   d. process information and
6. A better means to control tools, machines and technical systems.

The latter two factors concerning the development of more efficient means to collect, store, transmit and process information and to control technical systems are of major importance today and are the variables that are altering societies throughout the world. Most people are acquainted with the elements that have brought about the communication and information revolutions of today. These include the telephone, telegraph, phonograph, radio, photography, motion pictures, television, and satellites.

The two major breakthroughs, however, and the developments which form the core of the information-systems revolution of the last quarter of the twentieth century, were the creation of programmable electronic computers and the invention of the transistor in the late 1940s. The computer provided the capability to manipulate and transform information; the transistor, the potential for small and reliable sensing and control devices so essential to the high-speed automatic collection and processing of information.

The fusing of computer technology and communication technology gave birth to information-systems technology, a new technology which has altered and will continue to alter the very existence of humankind.

The Information Revolution

In the 1950s there were some 1000 or so computers, but no microcomputers or microprocessors. In the late 1970s there were over 220,000 computers and some 750,000 microprocessors. During the current decade microprocessors are ushering in a technological revolution that, from all predictions, will have a greater and more profound impact on societies throughout the world than did any other technical event at any other time in history.

All aspects of living are being affected directly or indirectly; education, the home, agriculture, transportation, recreation and health care, to name a few. New uses and applications are being developed every day. Microprocessors provide the means for control of all forms of industrial and business operations providing what has been called intelligent automation. Microprocessors are used in oil refineries, chemical plants, paper mills, steel mills, power stations, research laboratories, offices, and homes. They are being used to control internal combustion engines to improve fuel economy and lessen pollution. The range of present and potential applications is staggering.

A critical turning point in the development of intelligent automation came about with the development of the microprocessor in 1969 when an engineer for Intel Corporation, M. E. Hoff, was searching for a better way to produce silicon chips for use in electronic calculators. He found it was possible to incorporate the entire central processing unit (CPU) of a computer onto a single silicon chip. Combining the microprocessor with additional chips to provide other functions such as memory, Hoff created a micro-sized computer.

The second critical turning point, which enabled the large scale application of microprocessors, was the development of the means to manufacture a silicon chip with tens of thousands of electronic components and complex circuits imprinted on it.

Silicon chips are about one-fourth the size of a standard postage stamp. This breakthrough reduced the size of electronic equipment and increased the power and flexibility of small computers, while at the same time costs were reduced on the order of 100,000-fold.

The construction and design of integrated circuits, the core of microelectronics, have improved so that greater numbers of transistors, resistors, diodes and other electronic components can be placed on a single silicon chip. In 1971,

Intel, Inc., following the work of their engineer, M. E. Hoff, brought out the microprocessor by putting the entire central processing unit of a computer on a chip. By 1980, the power and the capability of the microprocessor were increased by new manufacturing capability enabling the placement of 200,000 components on a single chip. The Japanese have chips in development that will contain 250,000 circuits. Currently manufacturers are working on integrated circuits with one million components and by 1990 they predict as many as 10 million transistors on a single chip.

The microprocessor has brought about the potential of robotics and with robotics there will be a continuing change in the nature and distribution of jobs. It is evident that most people in the world are entering a new world for which they are not very well prepared.

No technical development in history, including the computer, has had the potential of altering jobs and employment worldwide as has the development of microelectronics and the microprocessor. Not only will jobs be eliminated through intelligent automation, but many jobs will be lost in the manufacture of electronic products because they contain fewer parts than the products they replace. For example, the National Cash Register Company switched from the manufacture of mechanical and electromechanical cash registers to electronic cash registers and in the process reduced its workforce 25 percent.

Most educators are aware that we have truly entered a new era. The evidence is abundant. Yet, for the most part, the primary purpose and focus of education has changed little. The primary concern, and even justification, is still job, career or occupational preparation. This position is maintained even though there is considerable evidence that many programs are still preparing people for non-existing jobs and non-existing futures. This does not mean that work and jobs are not important nor that education to prepare for work is less important. The question is and always will be: "What knowledge and know-how is of most worth?"

One purpose of education should be to prepare people so they can adapt to new situations and control their own destinies. The role of educators in the technologies should be to determine what learning is of most worth in an ever changing, dynamic, worldwide technological society. In pursuing this issue, questions will range from, "What kind of technological society can we have, given the limits of our natural world and the entropy law?" to, "How can we redesign and implement a system that, as a minimum, provides for the basic needs of each and every citizen, including the provision of meaningful roles in society?" An overall answer to this question will certainly focus on the need for all citizens in a democratic society to

know about and understand the behavior of the various technological systems, sub-systems and their elements, so they can participate effectively in determining and controlling their collective futures. A democracy requires well-educated and knowledgeable citizens. Yet, in many cases, the nature of education is not compatible with the present and projected society in which it exists.

Technology, Democracy and Education

If we are to remain as free citizens in a democratic society and control our own destiny, then it is important that we control our technical means and direct and use them to attain agreed upon social purposes. To do otherwise will bring about a society controlled by an elite group who are knowledgeable in creating technical means and who can control the technical means for their purposes.

To alter the possibility and protect our freedom we must remember that a technological society is a knowledge society and requires new forms of literacy for all citizens to function effectively as free and responsible members of the society. It is critical in a democratic society that all members understand the multiple relations among various technical systems and human affairs.

We consider the study of biology, sociology and psychology as well as other fields of study to be essential

for the attainment of literacy about life, self and society. But for some reason, the study of technology is omitted even though the most casual observer can determine that endeavors by humans in creating technical means have brought about an evolution of the human species not possible by biological evolution alone.

The very survival of the human species and the evolution of society have depended not on the accessibility of resources or favorable climates but on the creation and use of tools, techniques and technical systems. Phillip Bock, the anthropologist, reminds us of the importance of tools in our society.

> If the world were arranged entirely for our convenience we should have no use for tools, but it is not. Matter and energy are seldom found in exactly the right forms or quantities to satisfy our needs. The sun rises and sets without regard to our desire for light or heat. Food and water do not appear whenever we are hungry or thirsty. And various obstacles come between us and the objects of our desires.

Much of the current structure and content of education was born and nurtured in another era. This is particularly true of those fields of education whose discipline base is technology. The primary change in this discipline is the

increasingly intellectual base. The creation and development of technical means is of the intellect and the technical means of today are more intellectual not less, more theoretical not less, and more conceptual not less. It thus seems accurate to conclude that unless the content and practice of these fields of education in the technologies are based on theories and concepts relating to the behavior of the technical means and the relation of these means to human beings, their societies and the environment, we cannot expect to educate citizens capable of creating and controlling technological systems today or in the future.

Throughout our society, there is a recognition that the intellectual capabilities and technological understanding of our citizens must be enhanced if we are to compete successfully internationally, and if we are going to manage successfully the technical, social, and environmental interfaces within our own communities. We need not only intelligent and creative workers, but also intelligent and creative citizens.

In what ways do the current fields of education in the technologies contribute to the education of intelligent and creative citizens for the world of today?

Over the years, one of the avowed missions of these fields of study has been to study industry. The usual

approach has been to find out what the practices were in industry for designing or making a product and then to develop and teach curricula to emulate these practices. It would be difficult to make the case that such curricula actually provided a true study of industry in the same sense that other disciplines study the behavior of the phenomena of their fields. For instance, if the practitioners professing to teach about industry had been involved in study and research about industry, then they have been involved very early in environmental issues, worker health and safety, community and worker control of industries, microprocessor controls in industry, quality control through better design, employee adaptability to technological change, the enhancement of innovation and invention, and productivity questions, among others. But they were not. The mentality is of an earlier industrial era, an era many do not want to admit no longer exists. It is interesting to find, however, that others have been awakening to the fact that the citizens of the United States are not very literate about the creation and use of technical means--tools, machines, materials, techniques and technical systems and the relation of the behavior of these elements and systems to human beings, society and the civilization process. Many people recently have become aware of the importance of technology in human affairs and how ignorant we are as a people of this relationship.

The Council for Understanding Technology in Human Affairs, the National Academies of Science and Engineering and the American Association for the Advancement of Science have sponsored meetings on the issue of technological literacy. The National Science Foundation has appointed a commission to develop plans for improvements in the teaching of science and technology in the public schools. The Alfred P. Sloan Foundation recently awarded $250,000 each to ten liberal arts colleges for the purpose of developing curricula to increase the technological literacy of liberal arts graduates.

Business and industry are heavily involved also. They are investing some $3 billion yearly to fill what they consider is an education gap between what people are learning in education institutions and what they need to be competent employees.

The proposed new mission for professionals in the field of technology education is to enhance the understanding of technology among all people, focusing on a purpose that is vital to our country and to each and every individual.

Technological Literacy

Traditionally educators have separated liberal education from technological education. Today, educators

from all segments of the spectrum are embracing the study of technology as a part of basic education and the new liberal arts. A new form of literacy is being called for, a technological literacy. What does it mean to be technologically literate?

If the question was, "What does it mean to be literate in French or Russian?", the reply would be that the student should be able to speak, read and write in the French or Russian language, implying a knowledge and understanding of the words, symbols, syntax and structure of the language as well as the ability to perform using the language. It also implies a knowledge and understanding of the history and culture of the countries where the language is primary. Similar criteria apply with respect to technological literacy.

Today, we live in a complex, interrelated, computerized technical society. The first requirement of a technological society is that it is an educated society, an enlightened and informed society. The best way to focus on the centrality of this rather obvious point is to remember that each and every person on earth is a member of the spaceship earth. The more sophisticated the spaceship and the more crew members, the greater the task of educating people to manage and control it for the safety and security of all.

It would seem that each crew member must have a level of literacy about the functioning of our complex ship so that they will be able to make informed decisions and will not become frustrated by its technical nature so that they fear it and become alienated by it. This requires citizens knowledgeable about the characteristics, capabilities and limitations of the technological environment of the spaceship and the impact of their choices about the technical design of the spaceship on their future and the future of unborn generations.

The creation and use of technical means is a large and complex area of human intellectual activity which has evolved over the centuries and has had great social and psychological impact, but is little understood by society. And as critical as the understanding of technical systems is, as a basis for determining public policy and the management and control of technological systems, little effort has been made by public education to address the issue of technological literacy.

A large portion of our population lives in total ignorance about technical systems; their creation, evolution, capabilities, operations and limitations. Most live with perpetuated myths and folk knowledge that detract from true understanding. However, many people are becoming aware of the significance of the problems. For instance,

concern has been increasing about the issue of technological literacy. It has become a critical issue because of the problems of society resulting from what is called an industrialized or corporate technical society.

Institutionalized or public education has always focused on literacy and training for the corporate or industrial need. These training programs are called vocational, occupational and career education. The education system has become linked more closely to the needs of business and industry through these programs. The type of literacy required by this approach to literacy is job specific, less complex and seldom transferrable to new and evolving technical systems, a fact that is proven each time jobs are eliminated by technological change or obsolescence, as in the steel industry.

The other form of technological literacy focuses on the role of the individual in a free society as a citizen of a community, state, nation and world who functions in many roles and is responsible for the proper functioning of the spaceship today and for the long-term sustainable future. This is a much more complex level of technological literacy than the literacy required to obtain and sustain a job in a corporate enterprise.

There are many ways of structuring a program of technological literacy. An economist would focus on

the production function, an engineer on the technical, an anthropologist on the cultural and a sociologist on the social. None of these approaches is sufficient to structure a program of technological literacy today. What is needed is the focus of the technologist who is concerned with:

> "the study of the creation and use of technical means--tools, machines, techniques, technical systems--and the behavior of technological systems in relation to people, their societies, the environment and the civilization process."

The technological literacy of today and tomorrow must be based on a unifying, integrating study of the behavior of natural, technical and social systems and their interrelationships.

The New Literacy

The new literacy requires a new knowledge base incorporating the study of humankind; other cultures; technical and social systems and the behavior of these systems; processes of decision making; change processes; the history of technical means; goals and values in human societies; technological assessment; the interrelation of systems and the behavior and control of systems, both technical and social; the invention and innovation process and new technologies and technological systems including

energy systems, transportation systems, communication systems and production systems; and the process for designing new technologies and new social and technical skills, among others.

The new literacy must also incorporate the concepts, relationships, and consequences of technical means, together with knowledge and know-how in the appropriate selection and design of technical means and the process of transfer and adoption of new means into society with the least impact on people, the social system or the environment.

Thus, the focus of the new literacy is on the process of creating, using and assessing technical means at several levels. These levels range from a knowledge of the function and use of tools in the broadest sense of the term, to the design of products produced by people using tools, and the use, relation and impact of the products on people, society and/or the environment.

Most efforts concerned with technological literacy have focused on knowing about and using tools or on assessing the impact or effects of technical means. Both are restricted efforts and fail to attain a true literacy. All too often it has been assumed that a casual encounter with tools or the reading of a book or two on technological and social change will produce a technologically literate person. This surface treatment fails to comprehend the

complexity and interrelatedness of the task. True literacy will require a sustained effort over time to develop knowledge and understanding of the abstract concepts upon which the technical world has been created and functions. This level of understanding cannot be gained from hearing or reading about inventions and technical systems. What is required is direct and sustained involvement in the processes of the technologist. The mind must be prepared to be capable of observing and establishing differences, similarities and relationships. Human beings are not only perceptual beings, they are also conceptual. They are capable of learning and using technological modes of thought; the intellectual processes or methods of inquiry used by technologists.

A significant part of the literacy issue is language. Language is not just a means of communicating thoughts, ideas, concepts or technical information; it also structures the way people perceive themselves and how they act and function. Being technologically literate requires that the individual be conversant in several technical languages, including the symbolic languages of the various systems.

Finally, to be technologically literate requires a knowledge and understanding of systems.

Technological systems are composed of elements that are related and which interact in some way. Everything

exists in relation to other elements within an immediate and total environment. This means that there is some context within which an element, particle, person, tool, event, action or some other part of a system, acts and is acted upon. Perceiving the dynamics of a system requires the identification of some central theme, function or behavior, whether the concern is with the composition and behavior of a given material or of an electronic communication system.

First steps in comprehending a system often involve classification, either at the micro or macro levels. Classifying is the process of ordering and organizing that which is observed about component elements or parts. By classifying or ordering the elements of an on-going dynamic event, a beginning is made in the understanding of the behavior of the element in relation to other elements.

There are different types of classification systems designed for different purposes. Some merely group like objects or elements, as is done in the Dewey decimal or Library of Congress systems for classifying books, the Department of Commerce system for classifying industries, or the Department of Labor system for classifying occupations. These might be referred to as static systems.

Taxonomic analysis is another way to classify the component elements of a system. A taxonomy orders elements according to a central theme, a hierarchy, and relationships.

Certain universal technological endeavors exist in all societies at some level of sophistication. They include the means of producing artifacts, transporting goods and services, and transmitting information. Each of these systems can be classified and analyzed as sub-systems according to function, activity, or problem category. Examples include categories such as manufacturing, constructing and processing; terrestrial, marine, air and space transportation systems; and systems of information transmission, storage, retrieval and use. To be technologically literate, a knowledge and understanding of the evolution, structure and behavior of these systems is essential, together with experience in designing, constructing, using and assessing technical devices associated with various technological endeavors in the several systems.

The Problems of Changing a Profession

If the current concern about technological literacy is valid. If people become truly committed to attaining technological literacy among the citizens. If those in the field of education at all levels accept the challenge. Then everyone will be involved in a long and arduous task.

Why is this so? The answer is clear. The present content and structure of most programs related to the study of technologies are not capable of providing programs that will produce technologically literate citizens. The wagons have been circled, the status quo protected.

The only answer to developing programs that are capable of producing technologically literate citizens is the elimination of many of the teacher education programs in the field, the administrators and the faculties of which insist on continuing antequated programs that produce technologically illiterate teachers.

The present structure has vestiges of trade and job analysis, occupational training, manual training and crafts. C. Daniel Miller, State Specialist for Industrial Arts in Alabama, has described the problem very accurately in the March 1983 issue of the ACIATE Newsletter. Miller notes: "As a state specialist for industrial arts I would be ecstatic if the programs I typically encounter were teaching the arts of industry. The only industry I see emulated is the village handyman and carpenter, or the local furniture maker at best. . .High technology here is a new carbide-tipped saw blade."

An evaluation of teacher education program specialities by faculty in various faculty directories illustrates where

part of Miller's problem begins. You will find a very diverse set of descriptors ranging from woods, metals, drawing, manufacturing, industrial safety, industrial hygiene, power, energy, printing, building construction, graphic arts, electronics, quality control and plastics to auto body/auto restoring.

Unless there is a close relationship between philosophy and practice, these rather strange curricular structures will continue. The written or unwritten philosophical position concerning purpose and mission dictates the choices made.

John Feirer, Executive Editor of Industrial Education, in his March 1983 editorial titled "What Student Teachers Tell Us" reported some rather startling facts which affect the status, importance and quality of industrial arts programs. Feirer reports that about one third of the student teachers stated that there was no course of study for the class to which they were assigned. Most critic teachers operated "off the cuff."

Over one half of the student teachers reported that no textbook was available in the classes in which they were participating. More than half of the student teachers were never asked to give a demonstration. These same student teachers reported that school counselors still assign

students to industrial arts courses in auto mechanics or electronics even though they cannot read. Many students assigned to their classes have physical and emotional problems which affect their ability to perform in an industrial arts laboratory.

Many industrial arts teachers are no longer involved in the study of industry or technology. Their programs have been altered to serve special needs students. Knowing the nature of many industrial arts programs in the public school this may be a worthwhile direction. Why? Because, finally, there is a specific justifiable role for industrial arts in the public school: take care of those who are discipline problems, handicapped and intellectually incompetent.

One wonders how we reached this state, given our rather noble mission. Is it because the vigorous programs of the past have stagnated as Everett N. Israel suggested in his two-part article in the January and February 1981 issues of Man/Society/Technology? Israel calls for establishing a new sense of direction. Is this possible, except as an esoteric exercise, when so many of the factors affecting industrial arts result from the establishment and operation of public policies in which the profession has had no role?

Many times over the last several decades members of the profession have tried to set new directions, the latest

published effort being the Jackson's Mill Industrial Arts Curriculum Project. To date, there does not seem to be a movement by public schools or teacher education programs to adopt the proposed curriculum structure.

During the 1960s and '70s there were over twenty widely publicized curriculum efforts. And what has been the result? One need only review the findings of the Standards for Industrial Arts Project conducted by William Dugger and his staff at Virginia Polytechnic Institute and State University to find that the curriculum projects of the 1960s and '70s had little or no effect.

But there are effects. The effects are coming from abandoned public school and teacher education programs, from teachers opting for early retirement rather than continue the hassle and from a growing awareness by those still in the profession of the great discrepancy between the real world and the world of schooling.

Preparing for Change

One general conclusion that can be derived from observing the behavior of the field of education concerned with technology is that little change will take place without (1) a major shift in the philosophical base, and (2) a change in the focus of the programs from schooling to the content of the discipline of Technology.

This will require extensive research by practitioners in the profession, research that may be foreign to them because the questions are not schooling questions, but critical philosophical and discipline oriented questions.

The new philosophical and content base can be evolved through a research effort based on the question: "What learning is of most worth in the study of technology for citizens in their various roles in a democratic and highly technological society?" The question is highly relevant and significant. We are on the threshold of transitioning to another technological era brought about by a significant change in the nature of our technological systems and must be concerned about the question of: "What learning is of most worth?" There is a developing concensus that the learning that is of most worth is:

> that learning which serves individuals over the longest period of time and in the greatest number of situations as they live and participate in a meaningful and productive way in society.

The issue of intelligent citizenry is more critical than ever before. Being an intelligent citizen and worker today certainly involves knowing and doing in the technologies. Many recent choices with respect to our technical means have ended in disaster for some and near disaster for others.

This is true whether the issue is toxic wastes from industrial processes or the disemployment of people when the primary industry in a community is closed. When these things happen, people come to realize that they have lost control of their lives and that the communities they once believed were stable and sustainable for the long-term future are vulnerable to decisions made thousands of miles from their communities.

What we are discovering is that technological systems designed and developed by a mentality of another era are not sustainable. The problems and issues today concern the search for alternatives to present technical systems, either by designing new technical means or redesigning present ones. Successful designs will require new knowledge and understanding of the behavior of systems and the relation of the various elements and components of a system to the total. Today, our technical systems function on a global basis and decisions made by other businesses, industries, and governments affect directly business and industry in our own community.

Obviously, this requires, especially in a democratic society, the participation of all citizens if appropriate decisions are to be made and implemented. What learning is of most worth with respect to the design and control

of technical means at the community level by citizens? At the regional or national level? Simply answered, it is the knowledge and know-how that has to do with the behavior of technological systems.

What should all citizens know about technical means? What should they be able to do? Obviously, every citizen cannot know all there is to know about all of industry and technology. Therefore, the search must be for the structure of the discipline; the central themes, systems, concepts, and principles that provide insight into the behavior of industry and technology, not only technically but in relation to, and within, social-cultural contexts. The goal is control of technical means by technologically literate human beings. The means to attain control is knowledge and understanding of the behavior of socio-technical systems.

This moves the educational focus from the craft or trade mentality to technology as a discipline and a science, in the same sense biology, psychology, sociology, and other fields of study are disciplines and sciences. This, of course, means rejecting the use of the word technology to describe things, hardware, skills, industry, techniques or social phenomena. A better descriptor for these elements in society is technical means. For example, an automobile is a technical means created to transport people. Technology,

as a discipline and as a science*, can then be defined as:

> the science of technical means and human adaptive systems, including the study of the creation, evolution, utilization and behavior of technical means and adaptive systems in relation to human beings, society and the environment.

A New Research Base

The definition of technology provides clues to research and scholarly activities that would be meaningful, cumulative, and have long-term application. For instance, studies concerning the creation and evolution of technical means and systems would provide insight into the relation of these means and systems to human beings and society, thus establishing data for the derivation of concepts and principles concerning their behavior.

Understanding how technical means are created would aid in improving our ability to design and create appropriate technical means for our communities. Research pertaining to use of technical means and systems would provide

*Science: Knowledge covering general truths or the operation of general laws especially as obtained and tested through scientific method. A system or method based on or purporting to be based on scientific principles.

insight into appropriate procedures as well as problems associated with the adoption and use of technical means by society. The latter knowledge could then be used in the design of alternatives to our present problem-plagued technological systems or for the redesign of current systems to attain a greater degree of compatibility with human beings, their communities, and the environment.

Research on the technical aspects of systems would focus on the behavior of material transformation processes. However, the operational behavior of systems and sub-systems would focus on techno-social relationships, perhaps one of the more difficult categories of research. In this research the concern would be the relation of technical means and systems to individuals, communities, work and employment, and the natural environment. Here, the attempt would be to derive concepts and principles that could be used to predict the effects of the introduction of a new technical means into a social and natural context. Involved is the process of assessment and the prediction of probable impacts and risks.

Other research categories implied by the focus on technology as a discipline would be state of the art studies about evolving technical means as well as public policy studies concerning the adoption and use of new technologies. Included in the latter would be studies

concerning employee adaptability to technological change and the appropriateness of given technical means and systems with respect to quality of life and sustainability of communities. Questions related to work and its meaning and preparation for work would be natural research problems. For instance, what kind of education will all people require for work in the 21st century? When is the best time to prepare people for work? For specific jobs? What intellectual, physical and social skills are required?

Each of the above research efforts would contribute to the evolution of the content and structure of technology teacher education programs. This is a separate and distinct, yet related, research category that must be pursued.

Educational or pedagogical research questions must be redirected, the same as industrial and technological ones. The question of educating all people for the complex technological world they inhabit will require research concerned with the entire spectrum of education. Related to pedagogical research are questions concerning the diffusion and adoption of research findings and the design, development, and evaluation of change models that can ensure the continued evolution of the field of education concerned with technology.

Preparation of Professionals

In the final analysis the solution of the problem is a human one. It is the selection and preparation of people who can initiate and carry out the changes required.

In the field of education this problem rests largely with the undergraduate institutions that prepare teachers for the public schools and the graduate institutions that prepare faculty for the teacher education institutions. In both cases radical surgery is needed including consideration of the elimination of programs. Many teacher education programs are too small, poorly staffed and inadequately equipped to provide any semblance of adequate teacher preparation for the study of technology today. Many that are adequate in size, have appropriate facilities and are well staffed have changed their mission to the preparation of technicians for industry rather than educators for the public schools. The call for radical surgery, therefore, is in order because of the seriousness of the mission and because all institutions and faculty have been aware of the great need for change for at least the last 20 years. It is now time to act.

We cannot continue to sanction as a profession those who refuse to provide the future citizens and future teachers with the education required. To do so will only contribute to the continual demise of a very necessary component of education.

To believe the required changes will take place because they are called for or a public announcement is made is wishful thinking, of course. So what is the answer? There do not seem to be any answers individually or locally. There are answers if the problem is approached collectively and nationally.

Redirecting the Profession

The profession has lost its sense of mission, has become fragmented and has no means to adequately affect public policy in any significant way. One way to alter the situation in a complex interrelated, politically directed society such as ours is to create a national center dedicated to aiding the profession in its new mission. Such a center, for many reasons, would be involved in issues related to technology and human affairs. The Center for Technology and Human Affairs, operated with a nationally recognized board of directors, would be involved in aiding the profession in meeting its challenge of designing and providing educational programs that prepare technologically literate citizens. It would be a center where the problems would be researched; where teacher educators could be retrained and certified; where standards for programs could be developed, where pilot programs could be designed and tested; where citizens and educators could meet with researchers and practitioners

to plan for the future, where program standards would be developed and where appropriate and accurate information about education in the technologies would be distributed on a national basis.

The profession needs a means to move beyond its present stagnated status. Our youth and our nation need long term leadership for technology education. The task will never be done. The technical base of society will continue to evolve. A National Center for the Study of Technology and Human Affairs could provide the level of academic and political leadership required for the development and implementation of appropriate public policy concerning education in the technologies.

The primary function of the center would be to provide the field of technology education with political influence nationwide.

A national center could be instrumental in establishing regional centers of excellence in specific areas of technology studies staffed by the best in the profession. These centers could serve not only as education centers where future teachers and teacher educators are prepared, but also as exemplary programs where other programs could receive information and assistance for improvement.

The National Center, together with regional centers of excellence, could provide the education community with

research based pilot programs where public school faculties, teacher education faculties, administrators and others could receive up-to-date information and training.

Eventually, with the leadership of a free standing national center, a nationwide network of excellence would be established. This nationwide network would provide the field of education, concerned with technology education, with a dynamic, change-oriented process that has the potential of meeting the challenge of continuous change in the technologies.

The education of our youth about the evolving technological culture is now and will continue to be one of the most important missions in education. What is needed is the means to carry out the mission at all levels of education in all communities throughout the nation. A prestigious, quality National Center is the means to aid in this mission, not only at this time of need, but in the future, by providing the means to remain on the forefront in what will always be a changing content and problem base.